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A REPLY TO Mr. *Robins*'s Remarks ON THE ESSAY UPON *Diſtinct and Indiſtinct Viſion* Publiſhed at the End of Dr. *Smith*'s Compleat Syſtem of Opticks.

By *JAMES JURIN*, M. D.
Fellow of the College of Phyſicians, and of the Royal Society.

Communi ſenſu plane caret, inquimus. Eheu!
Quam temerè in noſmet legem ſancimus iniquam!

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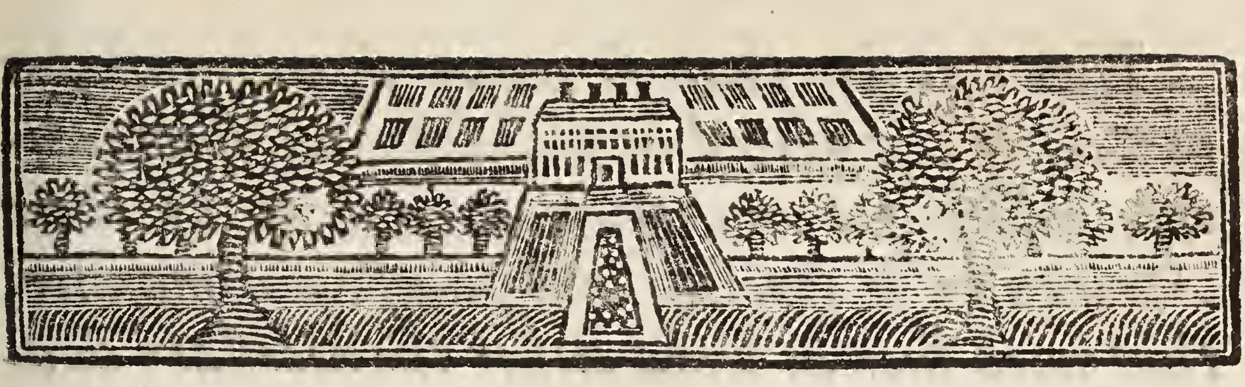

PREFACE.

THE ſtudy of Nature is attended with ſo many difficulties, ariſing partly from the variety of cauſes which either concur, or may be ſuſpected to concur in producing one and the ſame effect, and partly from the different circumſtances that diverſify the appearance of ſuch effect, that whoever applies himſelf to the ſolution of any Phænomenon hitherto unaccounted for, however well he may be qualify'd for ſuch an attempt, will find it neceſſary to uſe the utmoſt care and circumſpection to avoid deceiving himſelf and others. But ſuch is the fondneſs of mankind for their own opinions, upon how ſlight grounds ſoever they have entertained them, ſo apt are we all to take a bare probability for a demonſtrated and certain truth, that the caution we have been ſpeaking of, how neceſſary ſoever, is generally too little attended to.

Hence it is, that ſo many ſignal miſtakes are daily committed in philoſophical ſpeculations, which yet are often dreſs'd up by their Authors in ſo ſpecious and plauſible a manner, that with ſuch as want either the neceſſary qualifications, or the leiſure or inclination to examine them, they paſs for new diſcoveries, to the no little prejudice of Truth and uſeful knowledge, by preventing farther enquiry into what is looked upon to be already known.

It is therefore of ſervice to the Publick, that ſuch miſtakes ſhould from time to time be detected and laid open. And if thoſe who undertake to do this, have only Truth in their view; if they are careful to examine well before they cenſure, to reject nothing but what is really amiſs, to commit no errors of their own while they are rectifying thoſe of other men; if beſides this they write with that candour, which becomes men of Learning, without animoſity or paſſion, no way exaggerating the faults they condemn, but rather mitigating and excuſing them, rather endeavouring to preſerve the reputation of the writer they cenſure, by doing him full juſtice for what is right and worthy of praiſe in his performances, than to run it down and ruine it for a few miſtakes; they will, by ſuch a behaviour, deſerve the thanks not only of the Learned World in general, but even of the very perſon whoſe overſights they are correcting.

PREFACE.

When I firſt underſtood from an advertiſement in the publick prints, that my Eſſay was to undergo a publick examination, it was no ſmall ſatisfaction to me, to find by a Motto publiſhed in the ſame advertiſement, that I was fallen into the hands of a Gentleman, who had aſſumed the very character I have now been deſcribing. Inaſmuch as by that Motto he gave us to underſtand, that he thought it the duty of a good man not to paſs by in ſilence the miſtakes of others, but rather to deliver all mankind, if it were poſſible, out of the darkneſs of ignorance, and to bring them to the light of Truth; and that he was himſelf of ſo happy and equal a frame of mind, as to be ready to receive any animadverſions upon his own errours, with the ſame temper, that he would have others keep, while he is rectifying their overſights.

But this ſatisfaction of mine was of no long continuance. When the work came out, the very preface acquainted me, that this good man *wrote with* reſentment; *and not only ſo, but that he* held himſelf under no reſtraint *from candour, or good manners, or juſtice, but thought himſelf at liberty to* exaggerate the faults he cenſured, endeavouring *only* to avoid exceſſive exaggerations, *if there be any exaggeration which is not exceſſive.*

The reaſon given for this is the uncommon liberty, which, *he ſays,* has of late been taken with himſelf *in ſome* late diſſertations, *wherein* he has been uſed with groſs ill manners. *Much ſuch a reaſon this, as was given by the young lady, who walking with a Friend in the Mall, ſeizes the firſt pretty lap-dog ſhe meets with. Now, ſays ſhe, I am even with ſomebody. How ſo? ſays her Friend. Why ſomebody has ſtollen my dog, and now I have got ſomebody's dog in the room of him.*

But this writer may ſay, it is not ſomebody only he thinks fit to vent his wrath upon; it is not only thoſe Mathematicians in general who deal in Algebraical computations; nor only Mr. Euler, *and* his inſtructor *Mr.* John Bernoulli, *that he treats* with great plainneſs, without any apologies, or excuſes, or affected compliments, *unleſs the appellation of* inelegant computiſt, *which this young Gentleman is pleaſed to beſtow upon one of the oldeſt and moſt famous Mathematicians in* Europe, *be looked upon as an* affected compliment: *but it is Dr.* Smith *and myſelf, that he has peculiarly ſingled out as the objects of his juſt* reſentment.

I, it ſeems, am the REPUTED Author of the late diſſertations under the name of Philalethes Cantabrigienſis, and the other Gentleman is not only SUSPECTED of being my aſſociate, but merited, NO DOUBT, by ſingular ſervices, that high ſtrain of compliment, with which Mr. *Faber* is in one of thoſe papers addreſs'd, *and* Faber *is Latin for a* Smith.

He might have added, that Dr. Smith *and I both pretend to the love of Truth, were both bred at* Cambridge, *were both fellows of the ſame College, have been intimate Friends for many years, and are both of opinion that this Gentleman and his aſſociates underſtand juſt as much of good manners, as they do of Sir* Iſaac Newton's *firſt* Lemma.

But will all this amount to a ſufficient proof? Is it not poſſible that Mr. Robins, *notwithſtanding theſe ſuſpicions, may have diſcharged his choler upon the wrong perſons? He is indeed ſo* good, *as to ſay*, he is thus free, that he may do us the juſtice to give us an opportunity of acquitting ourſelves, if we are falſely accuſed. *But this, I think, is like the juſtice of hanging a man firſt, and trying him afterwards.*

If we ſhould now endeavour to acquit ourſelves of this accuſation, to remove this Gentleman's doubts and ſuſpicions; if Dr. Smith *were to tell Mr.* Robins, *what he has often profeſſed to other perſons, that he had no hand in thoſe papers; if to confirm this he were to remind him, that* Philalethes *himſelf has declared more than once, he wrote* alone and unaſſiſted; *if I*———————*But what ſignifies pleading, when execution is over? Mr.* Robins *has already vented his* Reſentment *to the utmoſt: with whatever* groſs ill manners *he has been treated, it cannot be denied that he has executed the* Lex Talionis *in its full extent.*

tent. If he were now to believe one or both of us to be innocent, all the amends we could expect, would be the civility of the Roman *Bravo, after ſtabbing the wrong man thro' the back, I beg your pardon, Sir, I took you for another perſon.*

Things ſtanding thus, I ſhall give myſelf no farther concern about this Gentleman's candor, or good manners, but ſhall content myſelf with examining how far he has obſerved the only reſtraint *he profeſſes to* hold himſelf under, what a juſt deference for Truth requires.

A
REPLY
TO
Mr. *Robins*'s Remarks.

THIS Gentleman begins with acquainting the Reader, that my Eſſay [a] *conſiſts of four general Heads.* He might as well have ſaid it conſiſted of ſix, or eight, or nine, or of four general heads different from thoſe he ſpecifies. But having little to object againſt what he calls the two firſt general heads, which contain much the greater and moſt conſiderable part of the Eſſay, and having, as he imagines, effectually refuted ſome paſſages of the third, and half a dozen lines at the end of the fourth, he was willing to make theſe victories appear as important as he could. If this be his reaſon, he is at liberty to qualify them by the name of general heads, though I myſelf never thought of ſuch a diviſion, the deſign of

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[a] Remarks, p. 92.

the third being only to ſolve a problem of Monſ. *De la Hire*, and that of the fourth to account for a particular appearance, which caſually preſented itſelf to me, while I was making experiments in order to that ſolution. But indeed this fourth general head is not meddled with by Mr. *Robins*: all he takes notice of being a ſhort reflexion ſubjoined to the end of it, which whether juſt or not, is of no conſequence to the reſt.

In the letter prefixed to my Eſſay I had acknowledged, that *my firſt entrance upon the following ſpeculation was principally owing to the hints and obſervations contained in Dr.* Smith's *book*: and upon this Mr. *Robins* is pleaſed to ſay, [b] *it appears, that I learnt the principles of Opticks from my friend's book.* But the ſpeculation contained in that Eſſay goes ſomething farther than the bare principles of Opticks, and the entrance upon it neceſſarily ſuppoſes the principles of Opticks to be already known.

He ſeems to be confirmed in this opinion, from my having [c] *expatiated upon the ſimple caſe of a uniform white object upon a black ground ſeen indiſtinctly more in detail, than he can ſuppoſe a writer would have done, to whom the ſubject was not new.* But another reaſon may be given for this detail. It has enabled me to give the ſolution of a great number of remarkable obſervations, part of which, I think, are new, and the other part have been thought worthy the notice of ſome of the beſt writers, but not accounted for by any.

Mr. *Robins* adds, [d] *After all he has treated of it but imperfectly, proceeding on a ſuppoſition, that the*

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[b] Remarks, p. 92. [c] Ibidem. [d] Ibidem.

light is uniformly ſpread thro' his circles of diſſipation; whereas he confeſſes at art. 220. *that the denſity of the light is different in different parts of theſe circles.*

Now, as I apprehend, in writing upon an intricate ſubject, the way to be underſtood is to put the ſimpler caſes firſt, and afterwards to proceed to the more compound. Accordingly, I treated of the light as uniformly ſpread, ſo long as the appearances I was explaining, did not require its inequality to be conſidered. And before I entred upon thoſe caſes, where it was neceſſary to conſider that inequality, I did in art. 197. expreſs myſelf in the following manner.

" This circle (of diſſipation) we have hither-
" to treated of, as if it were uniformly lumi-
" nous, or as if the rays of the pencil were
" equally and uniformly ſpread over the whole
" circle. But in reality the fact is otherwiſe:
" the rays are not evenly diſpoſed all over this
" circle, but are denſer in ſome parts of it than
" in others. And though in many caſes, and
" indeed in moſt of the phænomena above re-
" lated, this inequality of the denſity of the
" rays is not very conſiderable, nor occaſions
" any great change in the appearance, yet there
" are ſome few of them that will be remarkably
" affected by it; and there are ſome other very
" uncommon and ſurpriſing appearances, that
" are not to be accounted for from the common
" laws of Opticks, and depend wholly upon
" this inequality of the rays in different parts
" of the circle of diſſipation."

This paſſage in art. 197. which ſo plainly and fully expreſſes the reaſon of my proceeding, as well as the two hints I had before given in art 66 and 78, this ingenuous writer ſilently paſſes over, and ſays *I* CONFESS *at art.* 220. *that the denſity of the light is different in different parts of theſe circles.* This word *confeſs* I have obſerved to be very familiar with this Gentleman and his aſſociates, though they ſeem not to comprehend the meaning of it. They make no difference between a declaration made by way of caution to the Reader, before any controverſy ariſes, and a confeſſion extorted by the force of an adverſary's reaſons.

In art. 50, 51, 52. where I ſpeak of the meaſure of the Moon's diameter, as taken by the ancient Aſtronomers, and by the moderns likewiſe who obſerved by plain ſights, as the noble *Hevelius*, I treat of no other advantage they had above other men, but their practice in obſervation and the flatneſs of their eyes by age. But in the laſt of thoſe articles I gave notice, that I ſhould anon conſider the caſe of *Hevelius* in particular, and when I came to do ſo in art. 181, *&c.* I took into conſideration the advantage ariſing from ſights. However, I am ready to own, that it was an omiſſion not to conſider the ſights made uſe of by the ancients, at the ſame time that I was ſpeaking of the advantage they might have from practice and the flatneſs of their eyes by age.

I have ſhown in art. 90, 91, 92. that when a white circle bounded by a black circular line as its circumference, is ſeen by indiſtinct Viſion, the circumference appears broad and faint, and its penumbra ſpreading inwards, the white circle within it is thereby rendred too narrow. And when the diameter of the circle is ſmall enough to ſuffer the penumbræ from oppoſite parts of the circumference to meet in the middle, I have ſhown that the white circle vaniſhes, and a dark ſpot appears in the center.

In this Mr. *Robins* ſays, [c] I *have much miſtook*, and to ſhew that I have done ſo, he draws a figure, in which he tells us, *the ſpaces* GCHE *and* IFKD *will be deprived of light*; *but all without theſe ſpaces will be ſo much illuminated, that the axis of the eye can no where be deprived of light ſufficiently to produce ſo diſtinguiſhable a degree of darkneſs.*

Here I am much at a loſs, to know what this Gentleman means, by ſaying *the ſpaces* GCHE *and* IFKD *will be deprived of light*, whether he thinks they will be wholly deprived of it, or in part only; as alſo what is meant by *ſo much illuminated*, and *ſo diſtinguiſhable a degree of darkneſs*. I can therefore only acquaint him, that if the caſe he is conſidering, be the ſame with what I propoſed, where the radius of diſſipation is equal to that of the white circle we look at, and conſequently the penumbræ from oppoſite parts of the circumference meet in the center, then the ſpaces GCHE and IFKD *will* not *be deprived of light*; but on the contrary will be very near as luminous as any part of the intermediate ſpace. Likewiſe, *all without theſe ſpaces*, or the intermediate ſpace, which he ſays *will be ſo much illuminated*, will not be ſenſibly more illuminated than thoſe ſpaces themſelves. And *the axis of the eye*, which he tells us, *can no where be deprived of light ſufficiently to produce ſo diſtinguiſhable a degree of darkneſs*, will be ſo far deprived of light, as to produce a ſpot intenſely black. All which will eaſily appear to any one who carefully attends to my 92d article.

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[c] Remarks, p. 93.

But if the caſe Mr. *Robins* here conſiders, be one where the radius of diſſipation is leſs than the radius of the white circle we look at; then, in order to demonſtrate my miſtake, in ſuppoſing that where the penumbræ from oppoſite parts of the circumference coincide in the center, a black ſpot muſt appear; this judicious writer alledges a caſe, where thoſe penumbræ do not coincide, and conſequently no black ſpot can appear.

He is pleaſed to ſay farther that [f] *the appearance is not truly deſcribed.* But if the ſhade *appears uniform*, and I have deſcribed it as uniform, then I apprehend the appearance is truly deſcribed. As to the multiplication of the image, (of which and the appearance of the black ſpot, and abundance of other things, this Gentleman talks as familiarly, as if he had been well acquainted with them long before he had ſeen my Eſſay) I have very particularly and diſtinctly conſidered it in article 199 &c.

This [g] *multiplication of the image* Mr. *Robins apprehends to ariſe from ſome corrugation, or inequality of ſurface, to which that part in the eye, which is changed for the different diſtances of objects, is ſubject in its extreme tenſion either way, whereby the image of an object looked at out of the limits of diſtinct Viſion is multiplied.*

Here I cannot but agree with this ingenious perſon, that *the multiplication of the image ariſes from* ſomething *whereby the image is multiplied:* But that it *ariſes from ſome corrugation* in ſome *part of the eye in its extreme tenſion*, is, as I apprehend,

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[f] Remarks, p. 94.

[g] Ibid.

hend, a mere hypotheſis ariſing from ſome corrugation in ſome part of this Gentleman's brains, during the extreme tenſion they have undergone from *Philalethes Cantabrigienſis* for ſome years paſt. To him therefore I leave it to make out in what part of the eye, and by what means this corrugation is produced, and how the corrugation produces the multiplication of the image, and all the other appearances of the like kind which I have given an account of. Only for the ſake of ſuch readers, as may not have more penetration than myſelf, it would not be amiſs to uſe a little more perſpicuity, than when he tells us, "*in the circle* by a more multifarious appear-" ance a ſpot *in the center* is *in one ſituation* pro-" duced by the union of the different images *in* " *ſome one part.*" But poſſibly I may ſave him all that trouble by acquainting him, that the multiplication of the image often happens, when the eye is not *in extreme tenſion*, nay when in all probability the eye is not at all ſtrained, the image at firſt view appearing double or treble, with little or no perception of indiſtinctneſs, and the central ſpot in the circle appearing at firſt ſight, if the eye of the obſerver be ſufficiently near.

If *Hevelius*'s[h] *method of obſervation is little influenced by the longer or ſhorter ſight of the obſerver*; it is ſufficient for my purpoſe that it is influenced thereby, though but a little. Although he uſed two ſlits, he could look but through one at a time; and it is eaſy to ſee that an error of ſome determinate magnitude in proportion to the breadth of the ſlits, might be committed; but that this errour would be leſſened by the means I have laid down.

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[h] Remarks, p. 96.

The famous Monſ. *De la Hire* has publiſhed an obſervation, that when a ſpot is viewed thro' two pin holes near together, the ſpot appears ſingle at ſome one determinate diſtance ſuited to the eye of the obſerver, and at any greater or leſſer diſtance appears double. And from this he draws a concluſion contrary to the opinion of all other writers, that we ſee diſtinctly only at one determinate diſtance.

Now in article 105. I gave an account of ſome tryals I had made upon this occaſion, by which it appears, that I could ſee the ſpot ſingle ſometimes at 40, ſometime at 50, 60, 90 or more inches diſtance. This account therefore is directly contrary to Monſ. *De la Hire*. And yet Mr. *Robins*, *holding himſelf under that reſtraint, that a juſt deference for truth requires*, is pleaſed to ſay, I have [i] *informed him, that I had deceived myſelf by certain tryals to favour the ſingular opinion of Monſ.* De la Hire.

With the ſame regard to truth he ſays, [k] *I tell him, that Dr.* Porterfield *by experiments better contrived has cauſed me to change my mind.* I have told Mr. *Robins* nothing like this. My own experiments were equally contrary to Monſ. *De la Hire* with thoſe of Dr. *Porterfield:* but I build upon his experiments rather than my own, partly [l] becauſe my eyes are not now ſo good as his for ſeeing near objects, and partly becauſe his experiments were better contrived and more methodically made than mine. To me Dr. *Porterfield* is an abſolute ſtranger, but I thought this acknowldedgment due to Truth and common juſtice.

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[i] Remarks, p. 96.

[k] Ibid.

[l] Eſſay, art. 105.

The uvea, and that part of the uvea, by whoſe action I ſuppoſe [m] *the eye to be kept tenſe*, is not *inviſible.* Is this Gentleman acquainted with no Anatomiſt, no Profeſſor of Phyſick, that can give him better information? But perhaps he is all this while thinking of muſcles or muſcular fibres within the cryſtalline humour.

If in what follows [n] *I have the hardineſs to advance beyond the inſtructions of my Maſter*, as my Maſter is neither troubled with envy nor ill nature, which is more than can be ſaid of all Maſters, I am ſure he will eaſily pardon me. Had he laboured under any jealouſy of his diſciple, he would never have *beſtowed thoſe profuſe praiſes*, which ſo much offend Mr. *Robins*, upon the Eſſay on diſtinct and indiſtinct Viſion. But in regard to thoſe praiſes, I muſt own, my Maſter's affection, like Mr. *Robins*'s RESENTMENT, was ſomething too hard for his judgment.

Dr. *Smith*, it ſeems, [o] *has choſe to be very conciſe* in regard to the fits of eaſy reflexion and tranſmiſſion of light, upon which *I have adventured to expatiate.* His [p] *compleat Syſtem of Opticks*, we are told, *is upon this argument ſo very deficient, that theſe alternate fits of reflexion and tranſmiſſion of light are not ſo much as mentioned by name, where he has undertaken to exhibit Sir* Iſaac Newton'*s diſcoveries in Opticks.* [q]

There can hardly be given a better inſtance of the candour and ingenuous behaviour of Mr. *Robins* and his aſſociates with regard to Dr. *Smith*, than this laſt cited paſſage, which falls ſo naturally in my way.

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[m] Remarks, p. 96. [n] Ibidem. [o] Ibid p. 97. [p] Ibidem.

[q] Book 1. chap. 6, 7, 8.

Accipe nunc Danaum inſidias, & crimine ab uno
Diſce omnes.

This paſſage is worded with great art, and is highly worth the imitation of one ſet of political writers. Beſides the obvious ſenſe deſigned for the inadvertent Reader, there is another more latent, to be produced upon a proper occaſion. This cannot be better ſet forth, than by introducing a ſhort dialogue.

J. J. How, Mr. *Robins*! Do you ſay that *theſe fits are not ſo much as mentioned* in Dr. *Smith*'s Book? Pray remember the *reſtraint* you are to *hold yourſelf under, a juſt deference for Truth.*

B. R. I remember it very well, Sir. Catch me in a falſhood, if you can. My words are, *theſe fits are not ſo much as mentioned* BY NAME.

J. J. Oh, Sir, your moſt humble ſervant. Then you allow them to be mentioned, though not BY NAME. But will you venture to affirm, that they are no where mentioned *by name* in that Book?

B. R. I have not ſaid this. My words are, *theſe fits are not ſo much as mentioned by name,* WHERE *he has undertaken to exhibit Sir* Iſaac Newton'*s diſcoveries in Opticks.*

J. J. I do not find, that there is any one place in the book, *where* Dr. *Smith* has undertaken to exhibit all Sir *Iſaac Newton*'s diſcoveries in Opticks: but ſome of thoſe diſcoveries are exhibited in one place, and ſome in another. Do you mean therefore, that there is no place in the book, in which any of Sir *Iſaac*'s diſcoveries in Opticks are exhibited, *where* theſe fits are mentioned *by name?*

B. R. I ſee what you drive at. You will tell me, that in art. 507. where mention is made of an optical diſcovery of Sir *Iſaac Newton*, theſe fits are alſo mentioned by name. But I was too well upon my guard, to be liable to ſuch a refutation. After the word opticks I have placed a reference, whereby it appears that the word WHERE relates only to chap. 6, 7, 8. of the firſt Book.

J. J. I ſee by this, you ſhew no leſs ſkill in chuſing the place of your letters of reference, than in the choice of your expreſſions. But if this were your meaning, how came it to paſs that your letter of reference was not placed at the word WHERE? As it now ſtands, I doubt few readers will underſtand you.

B. R. I am not aſhamed of my ſkill in ſelecting thoſe expreſſions which contribute moſt to my advantage. I place my references, as I think proper, and if my reader uſes *careful attention*, he will underſtand me: if not, 'tis his own fault.

J. J. Your readers are much obliged to you. I muſt needs ſay, it behoves them to be very attentive. But pray, how came you to ſay, that the Syſtem of Opticks is SO VERY DEFICIENT on this account?

Since you have now explained yourſelf, let us conſider how your charge againſt Dr. *Smith* will ſtand. I think it will be to this effect: His *compleat Syſtem of Opticks is upon this argument ſo very deficient, that theſe fits are not ſo much as mentioned by name* in chap. 6, 7, 8. of the firſt Book. If this be too ſhallow an argument to prove the deficiency of the Doctor's book, you muſt acknowledge you deſign'd your reader ſhould underſtand you in another ſenſe. Pray tell me, *bonâ fide*, was not that your intention?

B. R. I don't underſtand all this catechiſing. But I think he was deficient in not mentioning them by name in thoſe chapters.

J. J. He did not undertake to exhibit all Sir *Iſaac Newton*'s optical diſcoveries in thoſe chapters: that could hardly be done without tranſcribing the whole book of Opticks. And as to theſe fits, he has in one of thoſe chapters mentioned the effect of them, and for the fits themſelves, which are the cauſe of that effect, he has referr'd his readers to Sir *Iſaac Newton*'s Opticks, a book in every body's hands, where they are largely treated of, and that was ſufficient for his deſign. As he intended to deduce nothing from theſe fits, he might in this reſpect be as conciſe as he pleaſed.

But if Dr. *Smith* has *been very conciſe* upon this ſubject, Mr. *Robins* has been more copious: if *I have had the hardineſs to advance beyond the instructions of my Maſter*, it is to be hoped this Gentleman has not committed the ſame fault, but has writ upon the beſt inſtructions his Maſter was able to give him. Let us therefore attend to the account he gives of theſe fits.

Now here, had I not before given myſelf the pleaſure of peruſing ſo many of theſe Gentlemen's writings, I ſhould have been greatly ſtruck with the perſpicuity of the deſcription, the *accuracy of the diction*, and the ſublimity of the ſtyle. For inſtance, *let it be conſidered, what is wanting to compleat the ſublime of this deſcription.*

"The [r] *rays* of light in *their* motion through
" the air, or any other tranſparent medium,
" *are* not alike diſpoſed in every part of *their*
" paſſage in regard to reflection and refraction;
" inſomuch that in ſome places, if *they* meet
" with another tranſparent ſubſtance, *they* ſhall
" enter it freely, ſuffering only a refraction at
" the ſurface upon *its* tranſmiſſion *through* into
" the tranſparent ſubſtance, but in other places
" *the ſame ray* ſhall be diſpoſed to be reflected
" back from any ſuch ſubſtance in *its* way."

A Reader leſs converſant in their works might poſſibly take this for nonſenſe. Such a one, when he meets with [s] *this dark ſpot*, *the* [t] *ſame ray*, *theſe* [u] *alternate diſpoſitions*, of which he has ſeen no mention before, would be apt to turn back in hopes to find ſome previous account of the ſpot, the ray, and the alternate diſpoſitions. But that is not Mr. *Robins* or his Maſter's way of writing.

Feſtinat, & in medias res
Non ſecus ac notas auditorem rapit.

But let us paſs over theſe beauties of ſtyle, and come to ſomething more material.

It is ſaid, [x] "Sir *Iſaac Newton* divides theſe
" intervals (between the fit of eaſy tranſmiſſion
" and the next fit of eaſy reflexion) into two
" equal parts, as here [y] C D is divided at g, and
" D E at h; and conſiders the whole fit of re-
" flexion to be extended between g and h, but
" ſtrongeſt at D, *&c.*

In another place we are told, [z] "Sir *Iſaac*
" *Newton* in the ſame ray makes the fit of re-
" flexion

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[r] Remarks, p. 98. [s] Ibid. p. 98. lin. 17. [t] P. 99. lin. 3. [u] Ibid. lin. 5, [x] Ibid. p. 99. [y] See Mr. *Robins*'s figure, p. 99. [z] Remarks, p. 111.

“ flexion equal in length to the fit of tranſmiſſi-
“ on, the experiments in the firſt part neceſſarily
“ requiring it.”

In a third place this Gentleman acquaints us, “ [a] that the proportion aſſigned by *Sir* Iſaac
“ Newton between the extent of each fit of eaſy
“ reflexion and the interval of the fits was the
“ reſult of mature deliberation, and neceſſary
“ towards producing the appearances.”

To all which I reply, that not a tittle of this is true. Sir *Iſaac Newton* no where *conſiders the whole fit of reflexion to be extended between* g *and* h; no where *makes the fit of reflexion in the ſame ray equal in length to the fit of tranſmiſſion*; has no where *aſſigned the proportion* pretended, or any proportion whatever *between the extent of each fit of eaſy reflexion and the interval of the fits.* So far was he from this, that he has never once conſidered, or ſo much as mentioned *by name*, or otherwiſe the extent of the fit of reflexion or of the fit of tranſmiſſion. All that he has conſidered, or had any occaſion to conſider, is the interval between the fits, without regarding what part of that interval was taken up by either of the fits.

This therefore being a matter of fact in diſpute between Mr. *Robins* and me, that Gentleman has nothing more to do, but to produce the paſſage of Sir *Iſaac Newton*'s Opticks, wherein ſuch proportion between the extent of each of theſe fits is aſſigned, or where that extent is ſo much as mentioned. And if he can find no ſuch paſſage in Sir *Iſaac Newton* himſelf, I ſhall content myſelf with a paſſage from any of his interpreters, who *had* an *opportunity of knowing his true mind.*

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[a] Remarks, p. 106.

If he ſhall ſay, there is not indeed any expreſs paſſage in Sir *Iſaac Newton*, nor yet in his interpreter, where ſuch proportion is aſſigned, or where the extent of theſe fits is at all mentioned, or appears to have been ſo much as thought of; but yet this proportion of equality is *neceſſary towards producing the appearances* related by Sir *Iſaac Newton*; I ſhall do myſelf the honour to teach him and his Maſter, how all thoſe appearances, even thoſe which in page 106 of theſe *Remarks*, are with ſo much confidence alledged againſt me, may be ſolved without admitting that proportion.

This undertaking, I apprehend, will be thought by Mr. *Robins* a piece of mnch greater preſumption, than what he had reprimanded me for before, of *taking upon me to improve upon Sir* Iſaac Newton, in relation to the extent of the fits of eaſy reflexion and eaſy tranſmiſſion.

But this laſt named piece of preſumption will need little Apology. Sir *Iſaac Newton* by carrying his enquiries into nature ſo far as he has done, has enabled thoſe that come after him, to proceed farther. He in one place tells us himſelf, that not having tried all the experiments he intended, his deſign was to communicate what he had tried, and to leave the reſt to others for farther enquiry.

Now my ſubject leading me to examine into the quantity of light reflected back from the firſt ſurface of a pellucid body, and this being a new enquiry into which neither Sir *Iſaac Newton*, nor any other Author, that I knew of, had ever entered, I was obliged to make an [b]experiment to determine it in the caſe of light falling perpendicularly upon glaſs; and thereby I found, that about $\frac{11}{100}$ of the incident light was reflected back at the firſt ſurface of the glaſs.

I then proceeded farther to enquire into the quantity of light reflected back from the firſt ſurface of other pellucid bodies; as alſo into the cauſe why that quantity is different in different pellucid ſubſtances: and herein I met with great aſſiſtance from two Principles eſtabliſhed by Sir *Iſaac Newton.*

One is, [c]that thoſe ſurfaces of tranſparent ſubſtances, which moſt ſtrongly refract the incident light, do alſo moſt ſtrongly reflect it.

The other principle is, [d]that every ray of light is ſometimes in a diſpoſition to be eaſily tranſmitted, and at other times in a diſpoſition to be eaſily reflected; and that theſe two different diſpoſitions return alternately at equal diſtances.

This engaged me to conſider attentively, what conſequences tending to my purpoſe might be drawn from theſe two Principles and thoſe obſervations of Sir *Iſaac Newton* on which they are founded. And as Mr. *Robins*, though he has condeſcended to borrow ſome of theſe from me, yet ſeems not at all to underſtand ſome others of them, I ſhall here lay them down more explicitly, as ſo many diſtinct Propoſitions, the truth of which will eaſily appear to thoſe who have carefully peruſed Sir *Iſaac Newton*'s obſervations.

PROPO-

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[b] Eſſay, art. 224.

[c] Opticks, Book 2. Part 3. Prop. 1.

[d] Ibid. Book 2.

PROPOSITION I.

The change of diſpoſition in a ray of light, to be at one time eaſily reflected, and at another time to be eaſily tranſmitted, cannot be inſtantaneous, but like all other operations of nature, muſt be made *paulatim* and by degrees.

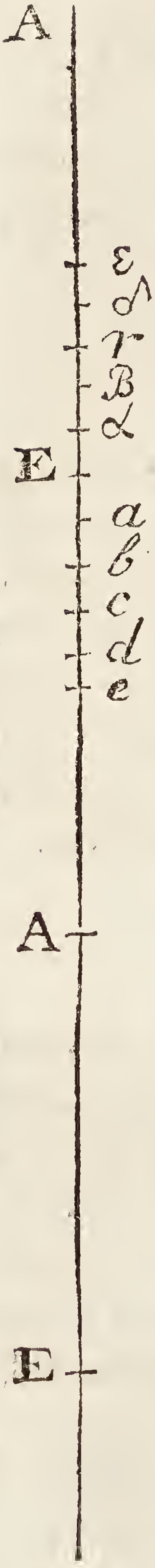
PROPOSITION II.

In every interval between two fits of eaſy tranſmiſſion, there is one point at which the diſpoſition of the ray to be reflected is the ſtrongeſt, and this point is preciſely in the middle of the interval, as alſo in the middle of the fit of eaſy reflexion. And in every interval between two fits of eaſy reflexion there is a like point, which is in the middle of the fit of eaſy tranſmiſſion.

PROPOSITION III.

While the ray is approaching this middle point of the fit of eaſy reflexion, its diſpoſition to be reflected grows ſtronger and ſtronger by certain degrees; and when the ray has paſſed this point, and is receding from it, that diſpoſition grows weaker and weaker by the ſame degrees. And the like may be ſaid of the diſpoſition to be eaſily tranſmitted.

For inſtance, if the line A E A E repreſent part of the progreſs of a ray of light, in which the intervals A E, E A, A E are all equal; and A be the point at which the ray is moſt ſtrongly diſpoſed to be tranſmitted, E the point at which it is moſt ſtrongly diſpoſed to be reflected, *i. e.* if A and E be the middle points of the two fits of tranſmiſſion and reflexion, the ray, in approaching the point E, ſhall at δ be more diſpoſed to reflexion than at ε, at γ more than at δ, at β more than at γ, and at α more than at β.



Alſo, when the ray has paſt the point E, and is receding from it, it ſhall at *a* be more diſpoſed to reflexion than at *b*, and *b* more than at *c*, at *c* more than at *d*, and ſo on.

PROPOSITION IV.

While a ray becomes more and more diſpoſed to reflexion, it becomes leſs and leſs diſpoſed to tranſmiſſion: and while it becomes leſs and leſs diſpoſed to reflexion, it becomes more and more diſpoſed to tranſmiſſion.

For inſtance, a ray paſſing from A to E, is more diſpoſed to reflexion and leſs to tranſmiſſion at δ than at ε, at γ than at δ, at β than at γ, at α than at β, and at E than at α. And having paſs'd the point E it is leſs diſpoſed to reflexion and more to tranſmiſſion at *a* than at E, at *b* than at *a*, at *c* than at *b*, and ſo on, till it arrives at A, where it is the moſt of all diſpoſed to tranſmiſſion and the leaſt to reflexion.

PROPOSITION V.

When a ray is moſt ſtrongly diſpoſed to reflexion, it may be reflected back from the ſurface of a tranſparent body, though the reflective power of that ſurface be very weak. But when the ray is leſs diſpoſed to reflexion, it will not be reflected back, unleſs the reflective power of the ſurface be proportionably ſtronger.

For inſtance, if the ray, being in the point E, do there fall upon the ſurface of a tranſparent body, whoſe reflective power is very weak, the ray may be reflected back, becauſe it is there the moſt ſtrongly diſpoſed to be reflected: but might not have been reflected back, had it fallen upon the ſame ſurface at the point *a* or α, where it is leſs diſpoſed to reflexion.

And if the ray, being in the point *a* or α, were there to fall upon a ſurface, whoſe reflective power is ſomewhat ſtronger than that of the former ſurface, it might be reflected back: but would not have been ſo, had it fallen upon the ſame ſurface at the point *b* or β, where it is ſtill leſs diſpoſed to reflexion.

In like manner, were the ray to fall upon the ſurfaces of other tranſparent bodies at *c* or γ, at *d* or δ, at *e* or ε, where it is ſtill leſs and leſs diſpoſed to reflexion; then in order to its being reflected back, the reflexive power of thoſe ſurfaces muſt be proportionably ſtronger.

PROPOSITION VI.

Hence it appears, that the part of the interval A A, in which a ray is diſpoſed to be reflected from the ſurface of a tranſparent body, *i. e.* the extent of the fit of reflexion in one and the ſame ray, as *a* α, *b* β, *c* γ, *d* δ, &c. is greater in proportion as the reflexive power of that ſurface is ſtronger.

Corollary. Therefore [e] *the ſpace, through which* the fit of reflexion *continues,* or the extent of the fit of reflexion, does not *depend altogether upon the medium, through which the light paſſes,* but partly *upon that, whereon the light falls.*

PROPOSITION VII.

When a ray of light falls obliquely upon a given refracting ſurface, the reflective power of that ſurface will be ſtronger in regard to that ray, as the obliquity is greater.

For inſtance, a refracting ſurface, which would be barely ſtrong enough to reflect a ray falling perpendicularly upon it in the point *a* or *α*, may by receiving it with a proper degree of obliquity, be able to reflect it back, when in the point *b* or *β*. And if the obliquity be ſtill greater, it may reflect the ray, when in the point *c*, or *d*, or *e*, where it is leſs diſpoſed to reflexion.

PROPOSITION VIII.

From the two laſt Propoſitions it appears, that the interval between the fits being given, the extent of the fit of reflexion in one and the ſame ray is not always the ſame, but depends upon the ſtrength of the reflexive power and the obliquity of the ſurface the ray is to fall upon, jointly, and increaſes as theſe two or either of them increaſe.

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[e] Remarks, p. 105.

PROPOSITION IX.

When homogeneal light, emitted or reflected from any natural body, falls either perpendicularly, or with any given angle of incidence, upon the plane ſurface of a tranſparent ſubſtance, the quantity of light reflected from that ſurface is to the whole incident light, as the extent of the fit of reflexion in any one ray, is to the whole interval between two ſubſequent fits of eaſy tranſmiſſion in the ſame ray. For as many rays will meet with the plane ſurface in any one point of the interval, as in any other point. Conſequently, the number of rays, that fall upon the ſurface in all the points of the extent of the fit of reflexion put together, will bear the ſame proportion to the number of rays, that fall upon it in all the points of the interval put together, *i. e.* the number of rays reflected will be to the whole number of incident rays, as the extent of the fit of reflexion to the whole interval.

PROPOSITION X.

When white or compound light falls perpendicularly upon the plane ſurface of a tranſparent ſubſtance, which indifferently tranſmits or reflects all the ſpecies of light, not one more than another; the extent of the fit of reflexion in every ſpecies of rays bears one and the ſame proportion to the interval between two fits of tranſmiſſion or of reflexion.

For all the ſpecies of light being indifferently reflected or tranſmitted, the reflected rays of one ſpecies bear the ſame proportion to all the incident

dent rays of that ſpecies, as the reflected and incident rays of any other ſpecies bear to one another. But by the laſt propoſition, the reflected rays are to the incident rays of any one ſpecies, as the extent of the fit of reflexion to the whole interval in that ſpecies. Conſequently, the proportion between the extent of the fit of reflexion and the whole interval is juſt the ſame in every ſpecies of rays.

PROPOSITION XI.

When white or compound light falls perpendicularly upon the plane ſurface of a tranſparent ſubſtance, which indifferently reflects or tranſmits every ſpecies of rays, the quantity of light reflected is to the whole incident light, in the ſame proportion, as the extent of the fit of reflexion in any one ray bears to the whole interval in the ſame ray.

This is evident from the two preceding Propoſitions.

Corollary 1. Hence [f] *it appears, that in common half the light incident upon any ſurface is* not *in a fit of tranſmiſſion, and the other half in a fit of reflexion.* Otherwiſe, *half the light* muſt be *reflected at all ſurfaces.*

Corollary 2. [g] *Hence* alſo *it appears*, how groſly erroneous it is to think, THAT WHETHER *more or leſs light be reflected from a body, the extent of the fits of reflexion in the incident rays is the ſame.*

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[f] Remarks, p. 104. [g] Ibid. p. 107.

From my experiment above-mentioned, concerning the quantity of light reflected from the firſt ſurface of glaſs, at a perpendicular incidence upon it from air, compared with the 11th Propoſition, it appears, that in this caſe the extent of the fit of reflexion is about $\frac{11}{100}$ of the whole interval.

And from this determination I have by a probable argument collected, that when light falls perpendicularly from air upon water, the extent of the fit of reflexion is nearly $\frac{6}{100}$ of the whole interval.

But now this precipitate Cenſor, without either trying or queſtioning my experiment, or pointing out any fault in the reaſoning, or ſo much as giving himſelf the leiſure to comprehend it, much leſs to examine carefully, whether my concluſion be reconcileable with Sir *Iſaac Newton*'s doctrine, has taken upon him to pronounce that this [h] *ſuppoſition*, as he is pleaſed to call it, is *abſolutely inconſiſtent with the very experiments from which Sir* Iſaac Newton *deduces his whole doctrine.*

In a ſecond place he is pleaſed to ſay, it [i] *is ſo abſolutely inconſiſtent with the eſſential principles of Sir* Iſaac Newton'*s doctrine, that the thought could never have been entertained by one of the leaſt degree of skill in the ſubject.*

Not content with this, he tells us in his recapitulation, that my [k] *aſſertion abſolutely deſtroys the whole theory eſtabliſhed by Sir* Iſaac Newton, *ſetting it at variance with almoſt every appearance, it is intended to ſolve.*

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[h] Remarks, p. 105. [i] Page 107. [k] Page 111.

Now if this be ſo, as I will not preſume to compare either my experiment, or my reaſoning upon it, with the experiments and reaſoning of Sir *Iſaac Newton*, I am content that my aſſertion be condemned as erroneous and falſe. But firſt let better judges than Mr. *Robins*, or Mr. *Robins*'s Maſter, determine, whether that aſſertion be not perfectly conſiſtent with all the experiments delivered by Sir *Iſaac Newton.*

In order to this, it will be convenient to lay open a capital miſtake, into which theſe warm-headed Cenſors are unhappily fallen, and upon which Mr. *Robins* has built all his objections againſt my aſſertion.

Sir *Iſaac Newton* in his ſecond book of Opticks, part the ſecond, after teaching us how to conſtruct his ſixth figure, in order to ſhew how the rings of colours in the plate of air between the object-glaſſes, and in the bubble of water are produced, ſuppoſes [1] A 2 to repreſent the thickneſs of a tranſparent body, at which the utmoſt violet is moſt copiouſly reflected in the firſt ring or ſeries of colours.

From this ſuppoſition he infers, by the help of his preceding obſervations, that H K will repreſent the thickneſs, at which the utmoſt red is moſt copiouſly reflected in the ſame ſeries; that A 6 and H N will denote the thickneſs, at which thoſe extreme colours are moſt copiouſly reflected in the ſecond ſeries; A 10 and H Q the thickneſſes, at which they are moſt copiouſly reflected in the third ſeries, and ſo on. After the ſame manner, and by the ſame means, he defines the thickneſſes, at which the intermediate colours will ſeverally be moſt copiouſly reflected.

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[1] See Sir *Iſaac Newton*'s figure.

After which, in order to define the latitude of the colours in each ring or ſeries, he ſuppoſes A 1 to deſign the leaſt thickneſs, and A 3 the greateſt thickneſs, at which the extreme violet in the firſt ſeries is reflected; and HI, HL to deſign the like limits for the extreme red, *&c.*

Upon this ſecond ſuppoſition of Sir *Iſaac Newton*, that the thickneſſes A 1 and A 3 are the limits of the reflexion of the extreme violet, and conſequently that the latitude of the reflexion of that colour is bounded by the ſpace 13, Mr. *Robins* takes it for granted, that this ſpace 13 is the extent of the fit of reflexion in a ſingle ray. If this were true, it would eaſily follow, that the extent of the fit of reflexion is always half of the whole interval between two fits of eaſy tranſmiſſion; and conſequently my aſſertion, that this extent in glaſs is but $\frac{11}{100}$, and in water but $\frac{6}{100}$ of that interval, would be effectually overthrown.

But who, in the name of blindneſs, can it be, that tells Mr. *Robins*, the ſpace 13 is the extent of the fit of reflexion in a ſingle ray? Can this information proceed from any one, who *had the opportunity of knowing Sir* Iſaac Newton'*s true mind?* Or from any body, that has conſidered his book of Opticks with *careful attention?* Is it poſſible, that perſons, who talk ſo much of *diſtinct and clear conception*, ſhould not be able to perceive the difference between the latitude of the colour reflected, and the latitude or extent of the fit of reflexion in a ſingle ray of that colour?

What Sir *Iſaac Newton* here propoſes to define, is not the extent of the fit of reflexion in a ſingle ray, or as Mr. *Robins* expreſſes it, *in the ſame ray:* but it is *the latitude of the colours.* The ſpace 13 is the latitude of the extreme violet, whoſe reflexion is compriſed within the limits 1 and 3. The rays of that colour are ſuppoſed to be *moſt copiouſly reflected* at the thickneſs A 2: and at the thickneſſes A 1 and A 3 the rays reflected are ſo few in number, as hardly to be ſenſible. And this will happen, whether the extent of the fit of reflexion in a ſingle ray be $\frac{11}{100}$, or $\frac{6}{100}$, or a much ſmaller part of the interval between the fits.

In order to apprehend this, we are to conſider, that the rays of the extreme violet, which are tranſmitted thro' the tranſparent ſubſtance at A, cannot all be in the middle, or be put into the middle of the fit of eaſy tranſmiſſion at that point A: but ſome of them muſt be paſt the middle of the fit, and others of them not arrived at the middle of the fit.

Now ſuch of theſe rays, as are in the very middle of the fit of eaſy tranſmiſſion at the point A, muſt be in the middle of the fit of eaſy reflexion at the thickneſs A 2; and ſuch of them as are in the middle of the fit of eaſy tranſmiſſion a little after they are paſt the point A, will be in the middle of their fit of reflexion at a thickneſs a little greater than A 2; and thoſe rays, that are in the middle of the fit of tranſmiſſion ſtill farther and farther beyond A, will be in the middle of their fit of reflexion at a thickneſs proportionably greater and greater than A 2; and ſuch of them, as are in the middle of the fit of eaſy tranſmiſſion at the point 1, will be in the middle of their fit of eaſy reflexion preciſely at the thickneſs A 3.

In like manner, ſuch of the tranſmitted rays, as are paſt the middle of their fit of eaſy tranſmiſſion at the point A, will be in the middle of their fit of eaſy reflexion at a leſs thickneſs than A 2; and ſuch of them as are more and more paſt it, will be in the middle of their fit of eaſy reflexion at a leſs and leſs thickneſs; and thoſe rays, which, upon their tranſmiſſion at A, are advanced half way from the middle of the fit of eaſy tranſmiſſion towards the middle of their next fit of eaſy reflexion, will be in the middle of this laſt named fit, preciſely at the thickneſs A 1; and thoſe, which are ſtill farther advanced, will be in the middle of their fit of eaſy reflexion at a thickneſs proportionably leſs than A 1.

But though the whole of theſe rays cannot be put into the middle of the fit of eaſy tranſmiſſion upon their entrance into the plate of air, or bubble of water, at A, yet the greater part of them will there be put either into the middle of that fit or very near it, and therefore, will be in the middle of their fit of eaſy reflexion or very near it at the thickneſs A 2; and conſequently the moſt copious and ſtrongeſt reflexion muſt be at that thickneſs, conformably to Sir *Iſaac Newton*'s firſt ſuppoſition, grounded upon his preceding obſervations.

And as the rays tranſmitted at A, at any diſtance from the middle of their fit of eaſy tranſmiſſion, will be leſs and leſs copious, as that diſtance is greater and greater; and will arrive at the middle of their fit of eaſy reflexion at a diſtance greater and greater from the point 2 on either ſide; the ſtrength of the reflexion muſt therefore decreaſe from the thickneſs A 2 both ways, and at ſome certain thickneſs on each ſide muſt be ſo weak as hardly to be ſenſible. All which is agreeable to Sir *Iſaac Newton*'s ſecond ſuppoſition, founded upon his preceding obſervations, whereby it appears, that at the thickneſs A 1 and A 3 the reflexion is hardly ſenſible.

Now as all this muſt happen from the greater copiouſneſs of the rays, that are tranſmitted in the middle of the fit of eaſy tranſmiſſion, than at a diſtance from it, without any regard to the extent of the fit of reflexion, whether a greater or ſmaller part of the interval, the limits of extreme violet, and conſequently thoſe of all the other colours will be juſt the ſame as Sir *Iſaac Newton* has determined, though the extent of this fit be only $\frac{11}{100}$, or $\frac{6}{100}$, or a much leſs part of the interval.

Therefore, when [m] *the extent of this fit* is *thus varied, only the quantity of light reflected from a tranſparent ſurface will be varied by changing the contiguous medium, but the colours* will not be varied, as Mr. *Robins* weakly ſurmiſes.

Nor is it true, to ſay, that *from the* [n] yellow this Gentleman mentions, *to the total blackneſs, each colour ought to emerge almoſt uncompounded.* Each colour, *where the leaſt ſimple*, will not only be *mixed with the contiguous colours of the ſame order*, but alſo *with thoſe of other* orders.

[o] *In particular the purple in* what Mr. *Robins* calls *the fifth order*, will not be *a pure violet without any mixture*, but *inclined to red.*

[p] Nor can any *dark interval* be poſſibly *ſeen between that and the red of the next order.*

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[m] Remarks, p. 105. [n] Ibid. 106. [o] Ibid. [p] Ibid.

In what this Gentleman calls *the* [q]*ſeventh order, a thickneſs of the bubble can be aſſigned, at which more than three colours will be reflected.* Some part of every colour will be reflected in this order, and conſequently a [r]*whiteneſs* will *appear.*

No [s]*ſenſible interval void of reflexion* can *appear between this and the order preceding.*

So that all the facts alledged againſt me by Mr. *Robins* in page 106 are wholly and abſolutely falſe, every colour appearing in the ſame order as Sir *Iſaac Newton* has repreſented, whether the extent of the fit of reflexion in the ſame ray be, as this Gentleman pretends, half of the interval, or $\frac{1}{100}$ or even $\frac{1}{1000}$ part of the ſame interval.

[t]*This ſhews, that the proportion* pretended to be ASSIGNED *by Sir* Iſaac Newton *between the extent of each fit of eaſy reflexion and the interval of the fits was* ſo far from being *the reſult of mature deliberation* in that Great Man, or any way *neceſſary towards producing the appearances,* that it is a groundleſs ſurmiſe of Mr. *Robins*'s inſtructor, and the appearances are not at all concern'd in it. I will not ſay, *the thought could never have been entertained by one of the leaſt degree of ſkill in the ſubject*; but ſurely it could not have been entertained by any one, that had attained to a clear and comprehenſive VIEW OF SIR ISAAC NEWTON'S PHILOSOPHY.

But here, I am ſenſible, ſome of the more curious and obſerving Readers will be apt to aſk, why I ſhould have given myſelf ſo much trouble about theſe allegations of Mr. *Robins*, which I have juſt been refuting. For were I even to admit what this writer ſo childiſhly ſuppoſes,

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[q] Remarks, p. 106. [r] Ibid. [s] Ibid. [t] Ibid.

poſes, that the latitude of reflexion of a colour compoſed of innumerable rays, were the ſame with the extent of the fit of reflexion in a ſingle ray, and were the extent of this fit in the ſame ray agreed to be no more than $\frac{11}{100}$, or to give this Gentleman all the advantage he is ſo deſirous of taking, no more than $\frac{6}{100}$ of the interval between the fits; yet ſtill, they may ſay, there needs no more than to lay a ruler acroſs Sir *Iſaac Newton*'s figure, in the manner he directs, and every one of the facts alledged againſt me will immediately appear to be falſe.

I anſwer, all this is very true, provided thoſe allegations are, as I at firſt thought, to be underſtood according to the plain and obvious meaning of the words. If by [t] *the yellow, which Sir* Iſaac Newton *ranges in the fifth order of colours*, we are to underſtand the yellow of what Sir *Iſaac Newton* calls the fifth order of colours, (and what man breathing is there, out of the *Schola P——na*, or the *Antrum Trophonii*, that can take it otherwiſe?) then the ruler will ſhew every one of Mr. *Robins*'s facts to be plainly and abſolutely falſe.

But what ſhall we ſay? Is it poſſible, that ſo *Good* a *Man*, one who conſtantly *holds himſelf under* that *reſtraint*, which *a juſt deference for Truth requires*, who *thinks it his duty to deliver all mankind, if it were poſſible, out of the darkneſs of ignorance, and to bring them to the light of truth*; Is it poſſible, I ſay, that ſuch a perſon can have advanced ſo many glaring falſhoods, not leſs than ſix or ſeven in the compaſs of a ſingle page. This ſeemed to me ſo utterly incredible, that I was under a neceſſity of taking thoſe allegations *not in*

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[t] Remarks, p. 106.

in the plain and ordinary meaning of the words, but in a new ſenſe which he thought fit to put upon them.

I now apprehend, that by *the yellow, which Sir* Iſaac Newton *ranges in the fifth order of colours*, is meant, the yellow, which Sir *Iſaac Newton* ranges in the third order of colours, but which Mr. *Robins* is pleaſed to range in the fifth order. In like manner by *the purple in the fifth order*, I ſuppoſe, is meant the purple of the third order; and by *the next order* to the fifth, is not meant the ſixth, nor the fourth of Sir *Iſaac Newton*, but the ſecond; and by the ſeventh order is meant the firſt of Sir *Iſaac Newton.* For though Sir *Iſaac* conſtantly numbers the ſeries or orders of colours from the black ſpot outwards, this Gentleman, without giving any notice of his intention, is pleaſed to number them the contrary way. A remarkable inſtance, if not of his *hardineſs*, at leaſt of his care and circumſpection not to miſlead his Reader.

Before I diſmiſs this point of the extent of the fit of eaſy reflexion, it will not be improper to take notice of a curious obſervation of Sir *Iſaac Newton*, the ſolution of which naturally follows from the principle above laid down, that thoſe rays are the denſeſt and moſt copious, which are tranſmitted in the middle of the fit of eaſy tranſmiſſion, and the reſt are gradually leſs denſe and copious, by how much they are farther removed from the middle of the fit, at their entrance into the tranſparent ſubſtance.

" [u] *At* firſt, ſays this accurate Obſerver, ſpeak-
" ing of the black ſpot, I thought there had
" been no light reflected from the water in that
" place,

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[u] Opticks, Book 2. Part 1. Obſerv. 17.

" place, but obſerving it more curiouſly, I ſaw " within it ſeveral ſmaller round ſpots, which " appeared much blacker and darker than the " reſt, whereby I knew that there was ſome re- " flexion at the other places, which were not ſo " dark as thoſe ſpots. And by farther trial I " found that I could ſee the images of ſome " things (as of a candle or the ſun) very faintly " reflected, not only from the great black ſpot, " but alſo from the little darker ſpots which " were within it."

Now as thoſe rays, which at their tranſmiſſion thro' the ſurface at A, are half way advanced from the middle of their fit of eaſy tranſmiſſion towards the middle of their next fit of eaſy reflexion, and conſequently are in the middle of this laſt fit at the thickneſs A 1, are ſo few in quantity as hardly to be ſenſible; it follows, that ſuch rays, as at their tranſmiſſion are ſtill farther advanced towards the middle of the fit of eaſy reflexion, and conſequently are reflected at a leſs thickneſs than A 1, as in the caſe of the ſmaller and darker ſpots within the great black ſpot, muſt be ſtill ſo much fewer in quantity, that the image even of a bright object, as a candle or the ſun, muſt appear dim and faint by their reflexion.

And hence appears the reaſon of what Sir *Iſaac Newton* [x] tells us, that we muſt not conceive the reflexion to be preciſely limited at the thickneſſes he has aſſigned, namely A 1 and A 3, but to decay indefinitely.

Here likewiſe it will be a proper place to take notice of another objection of Mr. *Robins*, tho' out of the order in which it was made.

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[x] Opt. Book 11. Part. 2. p, 201.

At the end of my Eſſay I had dropt a ſuſpicion of ſome miſtake in Sir *Iſaac Newton*, with regard to the extraordinary ſtrength of the white ring of light next the central dark ſpot, ſpoken of in his 23d obſervation. And this ſuſpicion was expreſſed in ſo modeſt a manner, and with ſo much deference to that Great Man, that how ill ſoever it might appear to be grounded, I had reaſon to hope it would eaſily be pardoned by candid Judges.

Now Mr. *Robins*, in order to make this ſuſpicion appear as abſurd as poſſible, is pleaſed to interpret my words *the extraordinary ſtrength of light*, by the expreſſions [y] *any ſuperior degree of brightneſs*, [z] *a light much ſtronger than that of the preceding rings*, [a] *a remarkable ſtrength of light*: from all which I gather, that this Gentleman did not ſee the difficulty, which occaſioned my ſuſpicion.

It is no way *extraordinary* for one ring to have *a remarkable ſtrength of light*; to have *a ſuperior degree of brightneſs*, or to have *a light much ſtronger than that of the preceding rings.*

But for a thin plate of air or water, as uſed in theſe experiments, to reflect a light as ſtrong, or nearly as ſtrong as that of white metals, may juſtly be called *extraordinary*, and is, I think, no way to be accounted for.

For whoever examines into the quantity of light reflected in this ring, by the help of Sir *Iſaac Newton*'s ſixth figure as he directs, will find that, at whatever thickneſs of the air or water any one ſpecies of light is moſt ſtrongly

F reflected,

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[y] Remarks, p. 109.

[z] Page 111.

[a] Page 112.

reflected, every one of the other ſpecies will be more weakly reflected. Conſequently, a conſiderable part of the incident light muſt be loſt by tranſmiſſion, though a white will ariſe from the mixture of rays of every ſpecies which are reflected.

But when a plate of white metal is reduced to the leaſt thickneſs art can give it, no ſenſible light is [b] tranſmitted, nearly all the incident light being reflected back.

If therefore Sir *Iſaac Newton* had meant, as I did once apprehend, and as Mr. *Robins* ſtill ſeems to think, that the white light of his firſt ring was equal, or nearly equal to that reflected from white metals, there had been juſt reaſon to ſuſpect ſome miſtake. But upon a careful reviſal of what that Great Man has in different places ſaid upon this ſubject, I now find, that though he ranges the whiteneſs of metals under the ſame order with the whiteneſs of the firſt ring in his bubble, yet he is far from ſuppoſing thoſe two whites to be of equal ſtrength; ſo that my difficulty is at an end.

Had it not been ſo, I could never have been convinced by the reaſon Mr. *Robins* gives me. He is pleaſed to ſay, that [c] *this particular appearance is a moſt obvious conſequence from the method, Sir* Iſaac Newton *gives for inveſtigating the ſeveral colours exhibited by thin plates. For it appears, that at this thickneſs of the plate* NO PART *of the light which enters it, arrives at its farther ſurface in a fit of eaſy tranſmiſſion.*

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[b] *Newton*'s Opticks, p. 223.

[c] Remarks, p. 110.

But this is ſo far from being *a moſt obvious conſequence* from Sir *Iſaac Newton*'s method, that it is utterly untrue.

SOME PART *of the light which enters* the plate, will *arrive at its farther ſurface in a fit of eaſy tranſmiſſion*, even upon Mr. *Robins*'s own ſuppoſition, that the extent of the fit of reflexion in the ſame ray is equal to half the interval between the fits.

But that extent being really no more than $\frac{6}{100}$ of the interval, as we have ſhown, a much more conſiderable part of the light will arrive at the farther ſurface in the fit of eaſy tranſmiſſion.

For all ſuch rays of the extreme violet, as are in the fit of reflexion any where between A and 1, muſt be in the fit of eaſy tranſmiſſion between 2 and 3, admitting the ſuppoſition of Mr. *Robins*.

And all ſuch rays of many other ſpecies, violet of all degrees, indigo, blue, green, yellow, and orange, and ſome part of the red, as are in the fit of reflexion within the diſtance of a very ſmall part of the ſpace A 1 after their entrance, will alſo be in a fit of eaſy tranſmiſſion between 2 and 3, admitting the ſuppoſition of Mr. *Robins*.

But allowing the extent of the fit of reflexion in the ſame ray to be no more than $\frac{6}{100}$ of the interval, a conſiderable part of the rays of every ſpecies muſt be in a fit of eaſy tranſmiſſion at a thickneſs leſs than A 3.

We come now to the principal and moſt important point of all thoſe, which this Gentleman has objected to.

In order to account for the multiple appearance of narrow objects, when indiſtinctly ſeen, I have [d] conſidered, what would be the picture of a lucid point, when too near or too remote for *Diſtinct Viſion*; and have ſhown that by means of the viciſſitude of the fits of eaſy tranſmiſſion and reflexion, ſome portions of the rays iſſuing from that point will be tranſmitted, and other portions will be reflected back, at their incidence upon the *cornea* and upon each ſurface of the cryſtalline humour.

From which it is deduced, that if the image of the lucid point were received upon a plane behind the *cornea*, or behind either ſurface of the cryſtalline humour, it would conſiſt of a middle circle ſurrounded with rings dark and luminous alternately.

To this Mr. *Robins* makes two objections.

One of which, if I underſtand it rightly, it being written in this Gentleman's uſual *Engliſh*, is to this effect.

The breadth of the dark rings formed at the *cornea* will be ſo exceedingly ſmall, that [e] *none of theſe rings can even on* my *own repreſentation of this doctrine be ever ſenſible.*

But had this writer attended more carefully to my *own repreſentation of this doctrine*, he could never have made this objection. By that repreſentation it appears, that what I ſuppoſe to be perceived by the eye, is not the ſingle rings formed at the *cornea*, nor the ſingle rings formed at either ſurface of the cryſtalline, but the combinations of thoſe ſingle rings, whereby larger rings are formed upon the *retina*, as manifeſtly appears from articles 216, 218, 219. in which laſt article I expreſſed myſelf in the following words. " When any parcel of theſe

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[d] Eſſay art. 209, &c.

[e] Remarks, p. 108.

" rings alternately light and dark, are ſo very
" narrow and cloſe together, as that they cannot ſingly be perceived, they will ALL appear as ONE ring, which our ſenſe will judge
" of as light or dark, according as the lucid
" rings in that parcel for number and breadth
" either exceed or fall ſhort of the rings adjacent.

Notwithſtanding this ſo clear a declaration, our bilious Cenſor will needs have it, that [f] *I ſuppoſe theſe rings, formed at the cornea, to be perceptible*, or as he afterwards words it, that I [g] *ſuppoſe the viſibility of theſe rings*: and from this he is pleaſed to infer, that *I am ignorant of the moſt obvious conſequences of thoſe abſurd conceptions, I had formed to my ſelf on this ſubject.*

But how, in the name of candour, came this Gentleman to ſay, that *I ſuppoſe theſe rings formed at the cornea to be perceptible?* My words are, " the picture of a luminous point, if it were re-
" ceived upon a plane placed before the cry-
" ſtalline, would conſiſt of a middle circle,
" ſurrounded with rings dark and luminous al-
" ternately." Now, I apprehend, there is a wide difference between conſidering what parts the picture would *conſiſt of*, and ſuppoſing that thoſe parts were large enough to be viſible. And there is no leſs difference between conſidering what the picture would be, in caſe it were received upon a plane ſo placed, and the ſuppoſing that in the human eye there is a plane actually ſo placed before the cryſtalline, and that this plane, like another *retina*, is endued with ſenſe, ſo as to be able to perceive the picture. This

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[f] Remarks, p. 108.

[g] Ibid.

This would indeed be a very *abſurd conception*, but it is no conception of mine.

The ſecond objection ſeems to be of more conſequence, and as I am ſenſible it may at firſt ſight appear plauſible to many readers, I intend to give it a diſtinct and particular examination. In order to which, it will be neceſſary in the firſt place, to ſtate the objection itſelf as clearly as I can.

But here I find myſelf greatly at a loſs. I would be glad to do this Gentleman all poſſible juſtice, and yet, after the moſt *careful attention*, I find it very difficult to know certainly what the objection is.

Mr. *Robins*, after ſpending [h] ſix pages in laying down what he takes to be Sir *Iſaac Newton*'s doctrine concerning the fits of eaſy tranſmiſſion and eaſy reflexion of the rays of light, comes to this concluſion. [i] *Hence appears how abſolutely this Gentleman has erred in this whole matter*, &c.

Now my difficulty is, to know, *whence* this *appears*; whether from all thoſe ſix pages put together, or from which of them, or from what particular paragraphs in them, or which ſeems the moſt natural, from the laſt paragraph only, which immediately precedes the word *Hence*. Never was man more gravelled either with oracle from *Delphos*, or *Ænigma* of *Sphinx*, with ancient prophecy of *Sibyll*, or modern prediction of *Noſtrodamus* or *Mother Shipton*, nor even with the works of that profound Philoſopher, who ſtands renowned to all poſterity by the immortal appellation of Σκοτεινὸς, though his writings are buried in everlaſting oblivion,

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[h] Remarks, p. 97—103.

[i] Ibid. p. 103.

For not to have been dipt in Lethe *lake*
Could ſave the ſon of P——bris *from to die:*
But Granta's *bard did him immortal make*
With verſes dropping dew of Caſtalie:

Spencer has put me out, but certainly never was any man more puzzled, than I have been in turning over thoſe ſix pages, to find the meaning of this myſterious word *Hence.*

What adds to the perplexity is, that part of the doctrine delivered in thoſe ſix pages is true, and part is falſe, as has been already ſhown, and might be ſhown in more inſtances than we have thought it worth the while to take notice of, and we cannot find that the whole, whether true or falſe, has any thing to do with the caſe in hand. For ſurely no argument can be drawn from the conſideration of white and compound light, iſſuing from innumerable lucid points, entering the firſt ſurface of a tranſparent body, and reflected from the ſecond ſurface, againſt our explication of a caſe, in which the light is ſimple and uncompounded, iſſues from one lucid point only, and is reflected back from the firſt ſurface, without coming to the ſecond.

In particular, the paragraph immediately preceding the word *Hence*, is either falſe, or utterly foreign to the purpoſe. For, if the light ſpoken of in that paragraph be ſuppoſed to come from a ſingle lucid point, there is juſt as much truth, as elegance of *ſtyle and diction*, in ſaying, *the light reflected from every point of either ſurface is the ſame in quantity of light:* for as much as the light will be reflected in greater quantity, where it falls more obliquely. And on the other hand, if the light be ſuppoſed to come from innumerable points, as is the caſe *in all the common appearances*, this paragraph has no relation to the caſe I propoſe, where the light comes from a ſingle lucid point.

Finding myſelf under this difficulty, I ſee no other way of coming at what this Gentleman meant to have objected, than by turning to the recapitulation at the end of his *Remarks*, where, in order to ſhew that I[k] *was not qualified to deſcribe even the very rudiments of Sir* Iſaac Newton'*s doctrine*, he has been ſo good as to refreſh the reader's memory, with a brief recital of three of the principal of my *abſurd conceptions.*

There he expreſſes himſelf in manner following.

[l] "The firſt principle laid down by Sir *Iſaac*
" *Newton* in the ſecond part of his ſecond book
" of Opticks is the inequality of the length of
" the fits of tranſmiſſion and reflexion in rays of
" different colours.

" But the deſcription and application of this
" doctrine, as given us by our author, do ne-
" ceſſarily ſuppoſe the lengths of theſe fits to
" be the ſame in all rays however different in
" colour."

Now if this be Mr. *Robins*'s objection, I muſt anſwer it by denying the latter part to be true. I ſay therefore, that neither my deſcription of this doctrine, nor my application of it, nor my deſcription and application put together *do neceſſarily ſuppoſe the lengths of theſe fits to be the ſame in all rays however different in colour.*

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[k] Remarks, p. 110.

[l] Page 111.

For firſt, in the deſcription of the doctrine, contained in art. 209, *&c.* there is no mention made of white or compound rays, ſuch as are compoſed of innumerable ſimple rays different in colour. I ſpeak, ſimply, of rays coming from a lucid point: and though a lucid point may be ſuppoſed either to emit compound rays, or rays homogeneal and uncompounded, yet the whole tenour of my deſcription can be applied only to ſuch rays as are either purely homogeneal, or principally ſo.

Therefore the deſcription is no way affected by Mr. *Robins*'s objection. If the lucid point emit homogeneal light only, or nearly ſuch, the picture of that point will conſiſt of a middle circle ſurrounded with rings alternately dark and luminous, as I have deſcribed it. And of this I take our animadverter to be fully ſenſible, in as much as he has not truſted to the deſcription alone, but has joined the deſcription and application together in his objection.

Now here I muſt acknowledge, that although the caſe I have particularly conſidered and explained in what Mr. *Robins* calls my deſcription of this doctrine, relates to homogeneal light only, yet I have afterwards applied this doctrine to phænomena, in which the light is compounded, as the light of the ſtars, of the ſky, *&c.* whereas it would have been proper to have applied it in the firſt place to ſuch phænomena, in which the light is homogeneal, or at leaſt principally ſo; after which, and not before, I ſhould have proceeded to the phænomena produced by compound light.

This omiſſion, occaſioned by the haſte in which that Eſſay was drawn up, for fear of retarding the publication of my Friend's book, I ſhall here ſupply by laying down ſome phænomena of homogeneal light, analogous to thoſe of compound light, which are recited in the Eſſay.

Take a fine thread of yellow ſilk, whoſe colour appears by the priſm to be homogeneous or nearly ſo, and ſtretch it acroſs a black plane. Then, if this plane be held too near the eye for the ſilk to be ſeen diſtinctly, you will have the appearance of two, three or more yellow lines divided by blackiſh lines. And if the eye be moved tranſverſly to the length of the ſilk, theſe yellow and dark lines will continually ſhift their places, ſeeming to roll over one another, like the lucid and black lines ſpoken of in the *Eſſay*, article 257.

The ſame appearances will happen, if a fine thread of black ſilk be ſtrained acroſs a yellow ground.

If a yellow ſilk be extended upon a red ground, or a red ſilk upon a yellow ground, juſt the ſame appearances will preſent themſelves, except only, that the alternate lines will now be yellow and red, inſtead of being yellow and black, as in the two firſt experiments.

If one and the ſame plane be divided by parallel lines into ſeveral grounds, as red, black, and white, and a yellow ſilk be ſtretched acroſs the parallel lines through all thoſe grounds, the plane may be held at ſuch a diſtance from the eye, as to make the ſilk appear double upon all thoſe grounds; and then the two yellow lines will appear ſtreight through the whole length of the plane: but the intervals between them will appear red upon the red ground, black upon the black ground, and white upon the white ground.

And if the plane be held at ſuch a diſtance from the eye, as to make the ſilk appear treble, there will be ſeen two red, black, or white lines between the yellow lines.

In theſe and many other experiments of a like nature, where the light is homogeneous, or nearly ſo, the explication given in the *Eſſay*, by means of the viciſſitude of the fits of eaſy tranſmiſſion and reflexion, will plainly account for all the appearances: and this ſeems to be a ſtrong preſumption, that the other appearances perfectly conformable to theſe, where the light of the object is not homogeneous, but compound, muſt alſo ariſe from the viciſſitude of thoſe fits, tho' the manner in which thoſe other appearances are to be explained, be different from the manner in which the former are explained in the *Eſſay*, where we have contented ourſelves with the ſolution of the ſimpleſt caſe, and have omitted that of the more compound.

But now it will be neceſſary for us particularly to conſider this more compound caſe, and to examine, whether *the application of this doctrine* to that caſe *do neceſſarily ſuppoſe the lengths of theſe fits to be the ſame in all rays however different in colour.*

And here, out of regard to Truth, I ſhall ſet the objection theſe Gentlemen make, in the ſtrongeſt and fulleſt light I can poſſibly deviſe.

Every ray of white or compound light, how ſmall ſoever, conſiſts of innumerable ſimple rays, all differing from one another, not only in colour, in degree of refrangibility and reflexibility, but alſo in the interval between the fits of eaſy tranſmiſſion and eaſy reflexion. Of this no body can be ignorant, who has looked

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into Sir *Iſaac Newton*'s Opticks, except only the author of the *Eſſay upon diſtinct and indiſtinct Viſion.*

Hence it is eaſy to collect, that if, at any point of the paſſage of a ray of white light, the ſimple rays that compoſe it, be every one in the middle of the fit of eaſy reflexion, the like will not again happen, till the ray ſhall have paſs'd through a diſtance immenſly great.

For if we ſuppoſe the compound or white ray to conſiſt of only 38 ſimple rays; and the interval between two ſubſequent fits of eaſy reflexion in the moſt refrangible of theſe rays, be to the like interval in the leaſt refrangible, as 63 to 100; and the intervals of the intermediate ſimple rays be as the numbers 64, 65, 66 —— 99; then all theſe ſimple rays cannot be together in the middle of the fit of eaſy reflexion a ſecond time, till they have paſs'd through ſuch a number of intervals of the moſt refrangible ray, as would ariſe from the numbers 64, 65, 66 — 100, continually multiplied into one another.

And if inſtead of 38, we ſuppoſe the number of ſimple rays, which compoſe the ray of white light, to be 380, 3800, 38000, or more, (for we know not where to ſtop) we may by this means arrive at ſo vaſt a number of fits, and conſequently at ſo immenſe a diſtance, that in the paſſage of a white ray from the ſun, or even from the fixed ſtars to the earth, it ſhall not twice happen, that all the ſimple rays which compoſe it, ſhall be together in the middle of the fit of eaſy reflexion.

Hence, if we ſuppoſe each ſimple ray to be reflected back from the *cornea* of the eye, only when it is in the very middle of the fit of eaſy reflexion, there will be immenſe odds, that all the ſimple rays compoſing a given white ray ſhall not be reflected back; and conſequently there is no reaſon to think, that any ring wholly dark can by this means be formed behind the *cornea*, or behind either ſurface of the cryſtalline.

And if in order to favour the ſuppoſed exiſtence of our dark rings, we admit every one of the ſimple rays compoſing a white ray to be diſpoſed to reflexion from any part whatſoever of the *cornea*, throughout one half of the interval between its fits; yet the number of theſe ſimple rays in every white ray being vaſtly great, we cannot preſume that more than one half of them, or more than one half of every white ray, will be reflected back from any part of the *cornea*. Conſequently, there can from this ſuppoſition be no ground to ſuppoſe, that any dark rings will be formed behind it.

Much leſs can we expect, that any dark rings ſhould be formed behind the *cornea*, if each ſimple ray be diſpoſed to reflexion from that membrane through only $\frac{64}{1000}$ or $\frac{1}{17}$ of its interval, as we pretend.

But farther, if we allow the ſimple rays to be reflected back from the *cornea* in greater proportion, as their incidence deviates more and more from the perpendicular, ſtill no dark rings can be formed, but only the circle of diſſipation will be gradually leſs and leſs luminous from the center to the circumference.

Thus far we have argued in favour of Mr. *Robins* againſt ourſelves, and hope we have done full juſtice to his objection. We now proceed to do the like juſtice to ourſelves and to truth, by conſidering whether the exiſtence of theſe dark rings cannot reaſonably be maintained.

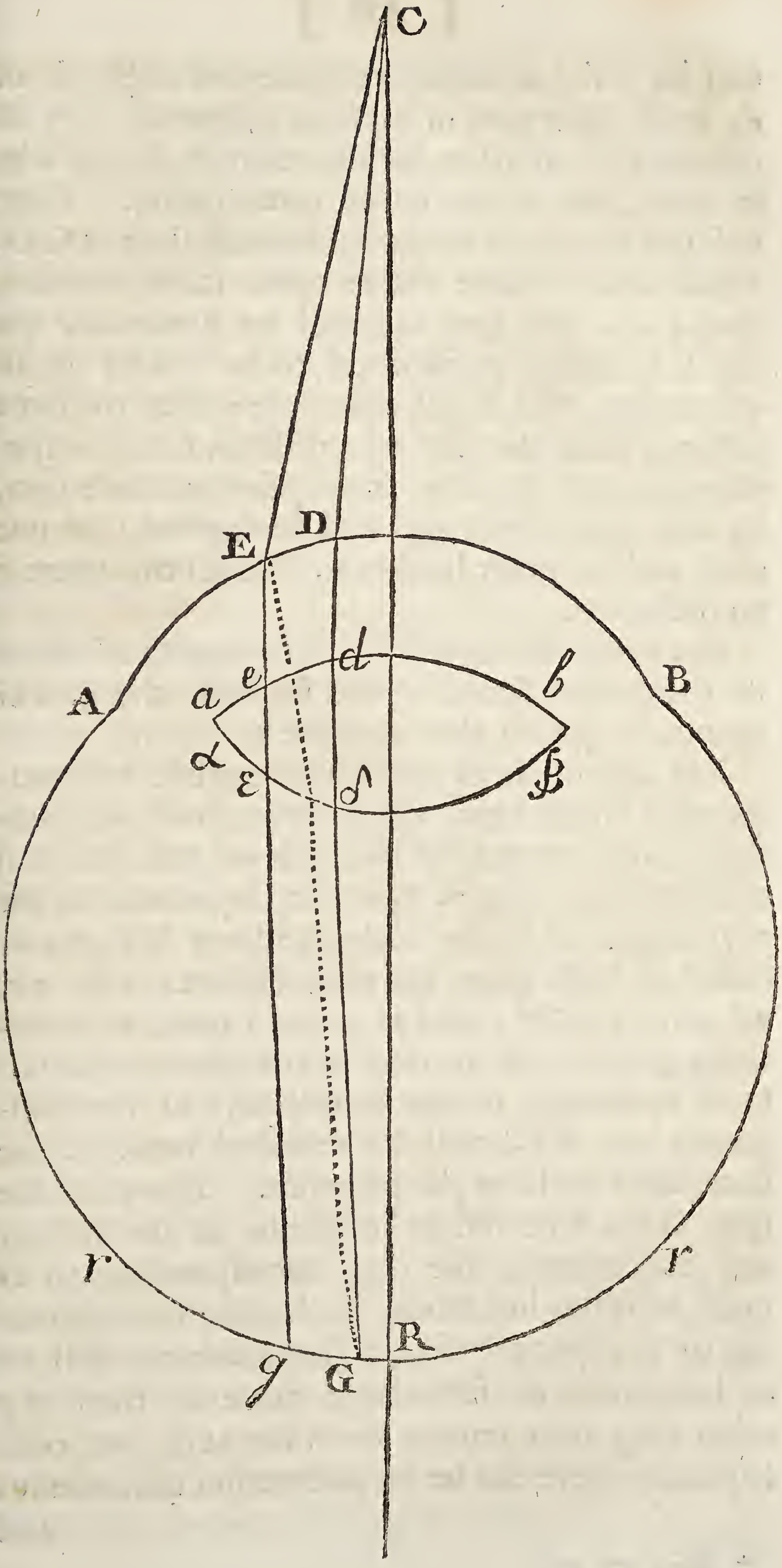
But firſt of all we muſt here deſire the Reader to take notice, that the luminons and dark rings we contend for, are not abſolutely, but comparatively ſo called. The former are not ſuppoſed to receive the whole of the light tending towards them, nor the latter to be wholly deprived of it. We ſuppoſe only, that the rings we call luminous, receive a proportion of light conſiderably greater than is received by thoſe rings which are called dark. This may be gathered from ſeveral paſſages of the *Eſſay*, where theſe rings are ſpoken of as more or leſs luminous, and more or leſs dark.

This being premiſed, we ſhall ſhew, that ſuch luminous and dark rings will, by means of the viciſſitude of the fits of eaſy reflexion and tranſmiſſion, be formed upon the *retina*, when the luminous point we look at out of the limits of diſtinct Viſion, emits white or compound light.

In order whereunto, let A B repreſent the *cornea*; ab the anterior ſurface of the cryſtalline; $\alpha\ \beta$ the hinder ſurface; rRr the *retina*; CR the axis of the eye; C a luminous point in that axis, too near the eye for diſtinct Viſion; C D a ſmall ray of light emitted from C, which falling upon the ſurface of the *cornea* at D, upon the anterior ſurface of the cryſtalline at d, and upon its hinder ſurface at δ, paſſes on to the *retina*, and there falls upon the ſpot G; C E ſuch another ray, falling upon the *cornea* at E, upon the two ſurfaces of the cryſtalline at e and ϵ, and laſtly falling upon the ſpot g in the *retina*.

Now at firſt let us ſuppoſe theſe two rays C D, C E, to conſiſt of ſimple or homogeneal light;

and


C
D
E
d
e
a
b
A
B
α
ε
δ
β
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G
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and let CD, at one of its incidences at D, *d*, or *δ*, be in ſome part of its fit of reflexion; but let the ray CE at all its incidences at E, *e*, and *ε* be in ſome part of its fit of tranſmiſſion. Then will the ſpot at G be dark, becauſe the ray CD, which ſhould have fallen upon it, is reflected back; and the ſpot at *g* will be luminous, the ray CE being tranſmitted to it. And as all other rays, which fall upon the eye at the ſame diſtance from the axis with CD and CE reſpectively, muſt be in the ſame caſe with theſe two, by this means two rings will be formed, the one dark and the other luminous. In all this there is no difficulty.

But when the rays CD, CE conſiſt of white or compound light, it will be ſaid, the ſpot G cannot be darker than the ſpot *g*.

For ſince each of theſe rays conſiſts of innumerable ſimple rays, all differing from one another in the intervals of their fits of reflexion and tranſmiſſion, only $\frac{1}{10}$ [m] part or thereabout of the rays contained in the compound ray CD can be reflected back from the three ſurfaces AB, *a b*, *α β* put together; and as great a part, or ſomething greater, on account of the greater obliquity of incidence, of the ſimple rays in the compound ray CE, will be reflected back at the ſame three ſurfaces put together. Therefore the ſpot G muſt be full as luminous as the ſpot *g*, and conſequently the ring correſponding to G muſt be full as luminous, as the ring correſponding to the ſpot *g*. Every ring therefore will be as luminous, or ſomething more ſo than any other ring more remote from the axis, and conſequently there can be no alternation of luminous and dark rings, as I have ſuppoſed. This I take to be the ſum of the argument brought againſt me.

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[m] Eſſay art. 236.

But theſe objecters forget, that the ſimple rays compounding a ray of white light have different degrees of refrangibility, as well as different intervals between their fits of tranſmiſſion and reflexion.

By means of theſe different degrees of refrangibility, each of the compound rays CD, CE, will upon its entrance into the eye, ſpread and dilate itſelf after the manner of the coloured ſpectrum in Sir *Iſaac Newton*'s firſt experiments; and will by this dilatation intermix with the neigbouring rays: on which account I muſt deſire theſe ingenious animadverters to look a little deeper and more attentively into the matter, than they have yet done.

Let us now ſuppoſe the rays CD, CE, to conſiſt of white light; and let G be the ſpot, on which the ray CD would have fallen, had it conſiſted only of homogeneal light of the extreme red, and on which the ray CE would have fallen, had it conſiſted only of homogeneal light of the extreme violet; and let g be the ſpot, on which the ſame ray CE would have fallen, had it conſiſted only of homogeneal light of the extreme red; and draw the bent line EG.

Then it is manifeſt, that the ſimple rays of extreme red, belonging to the compound ray CD, will fall upon the ſpot G: but the ſimple rays of all other colours, belonging to the ſame ray CD, by ſuffering a greater refraction, will almoſt all of them fall between that ſpot and the axis of the eye.

Alſo, the ſimple rays of the extreme violet, belonging to the compound ray CE, will fall upon the ſame ſpot G; and almoſt all the other ſimple rays compoſing it, by undergoing a leſs refraction, will fall without the ſpot G ſpreading as far as g.

The ſpot G will therefore receive from the compound ray C D all its ſimple rays of the extreme red, and from the compound ray CE all its ſimple rays of the extreme violet. And after the ſame manner you may eaſily ſee, that the ſame ſpot will receive the ſimple rays of all the intermediate colours from the ſeveral compound rays, that fall between D and E, that is, the ſimple violet rays of ſeveral degrees from the ſeveral compound rays, that lie neareſt to E, and the ſimple rays of the ſeveral degrees of indigo, blue, green, yellow and red, from the ſeveral compound rays, that fall ſucceſſively upon the *cornea* from E to D.

Now if all the ſimple rays we have been ſpeaking of, or the greater part of them for number and ſtrength, happen to be in their fit of tranſmiſſion, at their incidence upon the *cornea*, and alſo upon both ſurfaces of the cryſtalline, ſo as to fall upon the ſpot G, that ſpot will be luminous.

But if the greater part of theſe ſimple rays for number and ſtrength happen to be in the fit of reflexion, at the three above-named incidences put together; then the ſmaller part of them muſt fall upon the ſpot G, and conſequently that ſpot will be comparatively dark in reſpect of other ſpots, which receive a greater proportion of the incident rays tending to them.

And although not the greater part, but leſs than half of theſe ſimple rays be reflected back; but ſtill the ſpot G receive a leſs proportion of the light tending to it, than is received by another ſpot as *g* of the light tending to that, the ſpot G will be comparatively dark in reſpect of the ſpot *g*.

But farther, the ſimple rays of ſome colours, as the citrine yellow, are much ſtronger and more luminous than the reſt. For this reaſon, altho' the very ſame proportion of the whole of the ſimple rays tending to each of theſe ſpots, ſhould be reflected back, but more of the citrine yellow rays tending to the ſpot G be reflected, than of the ſame ſort of rays tending to the ſpot *g*, ſtill the former will be comparatively dark in reſpect of the latter.

Now that this muſt ſometimes happen, that an inner ſpot as G ſhall be darker than another as *g* more remote from the axis, will eaſily appear from what we have above demonſtrated, that by means of the dilatation of every compound ray at its entering the eye, any ſpot upon the *retina* as G will receive ſimple rays from a great number of compound rays falling upon the *cornea* between E and D.

Indeed, if the ſimple rays were not endowed with different degrees of refrangibility, and therefore the compound ray CD could keep itſelf entire and unbroken all the way as it tended to the ſpot G, then every ſimple ray compoſing it would have,

1. The ſame length of paſſage from the luminous point C to the *cornea* at D; and from thence to both ſurfaces of the cryſtalline at *d* and δ;

2. The ſame obliquity of incidence upon the *cornea*, and upon both ſurfaces of the cryſtalline; and by this means

3. The ſame proportion between the extent of the fit of reflexion and the interval of the fits, except only ſo far as that proportion would be a little greater in the more reflexible rays.

4. The ſame angle of emergence at the *cornea* and at the anterior ſurface of the cryſtalline; and conſequently,

5. The ſame proportions between the intervals of their fits, as have been obſerved by Sir *Iſaac Newton* in the ſeveral ſimple rays emerging from any refracting ſurface under one and the ſame angle, namely thoſe of 63, 64, 65—100 to one another.

And from all this it might eaſily be ſhown, by means of a figure reſembling the 6th above-named of Sir *Iſaac Newton*, continued to a great length, that $\frac{2}{10}$ of the whole ray CD muſt fall upon the ſpot G, and ſomething leſs of the ray CE muſt fall upon another equal ſpot as *g* more remote from the axis, ſo that no rings alternately dark and luminous could be form'd upon the *retina*.

But as only the extreme red of the compound ray CD does really fall upon the ſpot G, and the reſt of the light falling upon that ſpot is derived from the compound ray CE and the intermediate compound rays between that and CD, the caſe is far otherwiſe, as we ſhall ſhew more particularly by a compariſon between the extreme violet of CE and the extreme red of CD, both falling upon the ſame ſpot.

Theſe two ſorts of ſimple rays differ from each other,

1. In the length of their paſſage from the luminous point C to the *cornea* at E and D; to the cryſtalline at *e* and *d*; and to the vitreous humour at ε and δ;

2. In the obliquity of their incidence upon

the *cornea*, and upon both ſurfaces of the cryſtalline humour; and by this means they differ;

3. In the proportion between the extent of the fit of reflexion and the interval of the fits, that proportion being greater in the violet than in the red;

4. In the angle of emergence at the *cornea* and at the anterior ſurface of the cryſtalline, that angle being greater at both places in the violet rays than in the red, as may be eaſily ſeen; and conſequently by Prop. 15, 16. Lib. II. of Sir *Iſaac Newton*'s Opticks,

5. The proportion between the intervals of their fits, which at the ſame angle of emergence is that of 63 to 100, will now be altered, and the violet rays will approach towards the ſame interval with the red.

And what we have here obſerved of the violet rays, will alſo hold *mutatis mutandis* for all the intermediate rays between the extreme violet and the extreme red.

From which it follows, that the proportion of theſe ſimple rays tending to any ſpot as G, which is reflected back at the three ſeveral incidences above-mentioned, will not be conſtant, as in the caſe of the entire and unbroken ray CD tending to the ſame ſpot; but will be ſometimes more, ſometimes leſs. Therefore ſome ſpots as G muſt be darker than other ſpots more remote from the axis as *g*, and conſequently rings alternately dark and luminous will be formed upon the *retina*.

After the ſame manner it were eaſy to ſhew, that rings alternately dark and luminous might be formed upon a plane placed either between the *cornea* and the cryſtalline humour, or between the two ſurfaces of that humour. But ſince theſe rings could not be propagated to the *retina*, as in the caſe of homogenous light, but the ſimple rays, which form them, would diverge to diſtant parts of the *retina*, it is not worth while to trouble the Reader with the detail of theſe rings.

Thus much I have thought proper to reply, once for all, to the learned authors of theſe *Remarks*. I muſt needs ſay, the manner in which they have been pleaſed to treat me, and the obſervation I have made of their behaviour and regard to Truth upon other occaſions, gives me no ſort of inclination to have any thing to do with them. But yet, conſidering how doubtful it is, whether the fame of their lucubrations may extend ſo far as to *Petersburg*, or ever reach the ears of Mr. *Euler*; and it being the unanimous opinion of all Dr. *Smith*'s friends. that the animadverſions upon his book may be ſafely left, without any anſwer, to diſpaſſionate and intelligent readers, being ſuch as the writers themſelves will be aſhamed of whenever their ill grounded *reſentment* comes to cool; if I likewiſe were to make no reply, theſe Gentlemen might be in danger of having no notice at all taken of ſo elaborate a performance.

Now this, I am ſenſible, would be ſo cruel a mortification, after all the pains they have taken, and in particular might be ſuch a diſcouragement to the hopeful young writer, whoſe name is prefixed to their common labours, and who poſſibly, when he comes to ſtudy *ſuo Marte*, and to ſee with his own eyes, or to meet with abler inſtructors, may make ſome figure in the Learned World, that pure humanity induces me to oblige them with this one Reply. But I muſt deſire to be excuſed from going any farther. If what I now preſent them with, be ſatisfactory, it is well: If not, I leave it to them to make what anſwer they think fit. It will be eaſy to write as good a one to me, as any of thoſe they have given to *Philalethes*: eſpecially, if they keep to their uſual conduct, never to take notice of thoſe points, in which they find their opponent the ſtrongeſt, (that would be taking a bear by the tooth, or a bull by the horns) but rather to faſten here and there upon an unguarded expreſſion, or any little ſlip of inadvertency, as prudent generals always attack a town in the weakeſt part, and let the reſt alone. And to make this matter ſtill more eaſy to them, I do hereby, under my hand, give theſe Gentlemen full liberty, both of interpreting any paſſage of mine as they ſee convenient, and alſo of changing my words in their quotations, in as ample a manner, as they have ever uſed with *Philalethes*.

But in the mean time, it will be highly neceſſary, after ſo much as they have talked of their own *Remarks*, to keep one another in countenance as well as they can. In order whereunto, if I may preſume to give them my advice, the very day after they have peruſed this, they ſhould all meet at one of the moſt frequented Coffee-houſes, for my own entertainment I could wiſh it might be *Batſon*'s, and there, having got a few diſciples about them, ſhould publickly compliment one another upon the compleat victory they have obtained. This cannot but have a good effect upon ſuch hearers, as are unacquainted with the ſubject; and for the reſt, they are but few.

But above all things, I muſt recommend it to them, either to get a new Trumpeter, or at leaſt to take ſome care of their old one. The poor man is ſo grievouſly afflicted with the overflowing of the gall, that he cannot ſpeak three words about *Philalethes* or me, without working himſelf into a paſſion. I ſhould think a dozen or two of Mr. *Ward*'s pills might be of great uſe to him. When by this means the redundancy of his choler is a little abated, his declamations may be of ſome ſervice, at leaſt with the weaker and more credulous part of his auditors: whereas, in his preſent condition, all his outcries of *curſed nonſenſe*, *damn'd ſtupid*, and that conſtant Epiphonema, *he knows nothing at all of the matter*, can have no other effect, even upon the moſt ignorant, than to make every body conclude that his friends have the worſt of the argument.

I have ſome where heard a ſtory, I think, of a *Cobler* at *Paris*, who took great delight in attending the diſputations in the publick ſchools. One day a ſtudent took it in his head to ask this ingenious mechanick, what he did there. Oh, ſays he, I love dearly to ſee, who gets the better. What then, do you underſtand *Latin?* ſays the other. No, Sir, not I, not a word. Why then how can you tell, who gets the better? Oh, Sir, that's the eaſieſt thing in the world; for, if you obſerve it, he that has the worſt on't, always flies into a paſſion.

I leave theſe ingenious perſons to make their own reflexions upon this ſtory of the *Cobler*, and for myſelf, if hereafter I find myſelf in any miſtake, I intend to retract or amend it, when I have leiſure to publiſh a new edition of the *Eſſay upon diſtinct and indiſtinct Viſion*.

FINIS.

ERRATA in that Eſſay.

Art. 141. lin. 10. for 4,5462 read 4,3462.
Page 142. Col. 2. lin. 8. for *fall upon*, read *fall without*.

ERRATA in this Reply.

Page 8. lin. 15. r. *ſometimes*.
Pag. 18. lin. 10. for *and b* read *at b*.